Issued February 12, 1912.

United States Department of Agriculture,

BUREAU OF SOILS—CIRCULAR No. 61.

MILTON WHITNEY, *Chief of Bureau.*

U. S. DEPARTMENT OF AGRICULTURE,
Washington, D. C., January 19, 1912.

SIR: I have the honor to transmit herewith the manuscript of a report covering investigations of the Otero Basin, N. Mex., for potash salts, by E. E. Free, of this bureau, and to suggest that this article be published as Circular No. 61 of the Bureau of Soils.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

AN INVESTIGATION OF THE OTERO BASIN, N. MEX., FOR POTASH SALTS.

By E. E. FREE.

The geologic behavior of the soluble potash salts and the probabilities as to their occurrence in undrained basins in general have been discussed in Senate Document No. 190, Sixty-second Congress, second session. It is necessary here to recall only that they are accumulated and concentrated by the waters of the ordinary drainage, and that they will have been segregated, if at all, at that point where these drainage waters suffer their final and complete evaporation. Therefore, if potash is present on or near the surface of any undrained basin, it will lie in and under the sink or playa which occupies its lowest spot and forms the final resting place of its waters. Obviously, the first step in searching any basin for suspected potash is the examination of this central sink. But absence of potash there is not fully conclusive. Erosion and deposition, orographic movement, and climatic variations have resulted in an ever-changing topography, and present conditions may bear little similarity to those of the past. It is possible that beds of potash have been laid down in previous epochs only to be buried and concealed by later barren deposits. It is necessary then to supplement the examination of the central playa by such study of the general geologic history as

will throw light upon the probabilities of the deposition of salines during earlier geologic time, their existence beneath the present surface, and the presence of potash salts among them. In particular, search must be made for any direct evidence along this line, such as the records of deep wells, the composition of spring and well waters from the buried beds, etc.

All these inquiries look toward the discovery of the actual location of possible deposits of potash. There are, however, certain additional criteria as to the probable presence or absence of potash somewhere within the basin, the exact location remaining unindicated. These have to do with the matter of source. It is well known that potash salts, wherever found, are derived from the decay of potash-bearing rock minerals under the action of weathering and the surface waters. If, then, the rocks composing the drainage area of any undrained basin contain large amounts of such minerals, and if the waters now flowing over these rocks and into the basin are high in potash, potash deposits may be suspected. A scarcity of potash in rocks or waters strongly implies its absence from the basin.

In summary, the examination of a suspected area should include:

(1) A study of the central sink or sinks. Are there any potash beds on the present surface?

(2) A study of the geologic history. Are any buried saline beds probable?

(3) A chemical study of waters from any deep wells, deep-seated springs, etc., on the basin floor. Do the buried salines, if any, contain potash?

(4) A study of the composition of the rocks of the drainage area. Is there any visible source of potash?

(5) A chemical study of the present drainage waters. Is potash now entering the basin?

In the reconnoissance of the Otero Basin all of these questions were kept constantly in mind, and an effort was made to answer all of them as fully and finally as possible. The conclusions follow. The topographic and geologic characters of the region, which will be fully described elsewhere, need not be reviewed.

The sink of the basin is the old lake bed or playa west of the White Sands. It has not been minutely explored, but enough is known of it to warrant the assertion that its surface is everywhere composed of loose gypsum. This gypsum is usually more or less saline, and in one place (Lake Lucero) a bed of mirabilite, or crystallized hydrous sodium sulphate, lies just under the surface. No other deposits of segregated salts are known. A complete chemical analysis was made of the water-soluble portion of the loose gypsum overlaying the mirabilite bed, and the results are given in Table I.

TABLE I.—*Analysis* [1] *of the water-soluble constituents of the loose gypsum sand overlying the mirabilite bed of Lake Lucero.*

Constituent.	Per cent.	Constituent.	Per cent.
Sodium (Na)	16.90	Sulphates (SO_4)	37.47
Potassium (K)	Trace.	Carbonates (CO_3)	.05
Calcium (Ca)	.95	Bicarbonates (HCO_3)	.12
Magnesium (Mg)	22	Nitrates (NO_3)	Trace.
Chlorides (Cl)	.20		

[1] Analysis by R. F. Gardner, Bureau of Soils.

Tests for potash were also made on the icelike material of the mirabilite bed itself and on the loose gypsum from South Lake, the southern extremity of the old lake bed or sink. The latter sample contained a trace of potash, the former none at all. These tested materials occupy the lowest portions of the present playa, where potash would accumulate if at all. Its absence is nearly conclusive proof that it is present nowhere on or near the surface of the basin.

The complete results of the study of the historical geology can not be given here. It will suffice to say that the basin has shared the history of most of the other undrained basins of North America in that it is deeply filled with the débris of the surrounding mountains, and has been, at several times during the Quaternary and perhaps the Tertiary periods, the home of a fluctuating undrained lake. In the long series of expansions and contractions of this lake, entailed by its climatic vicissitudes, it probably often suffered complete or nearly complete desiccation, and each of these periods of desiccation must have been marked by the deposition on the lake bottom of all or part of the salts which it contained. It is very probable, therefore, that the buried beds of the valley will have considerable salinity. This does not mean, however, that the included salts are likely to exist in segregated and crystalline form. From a consideration of the varying supply of insoluble alluvium to the ancient lake, and from geochemical considerations concerning the concentration and segregation of the various soluble materials, it seems much more probable that any buried saline materials are in the form of saline sands and clays rather than separate beds of salt.

The direct evidence as to the chemical nature of the hypothetical buried salts is so meager as to be unimportant. Three waters of possibly deep-seated origin, have been analyzed and the results are given in Table II, but the sources of these waters are unknown and they offer no worthy evidence concerning the buried strata.

TABLE II.—*Analyses of waters of possibly deep-seated origin.*

[Parts per 100,000.]

Constituent.	Sample No. 1.[a]	Sample No. 2.[b]	Sample No. 3.[b]
Sodium (Na)	362	Undetermined.	500
Potassium (K)	Trace.	Trace.	Trace.
Calcium (Ca)	70	19	123
Magnesium (Mg)	None.	18	296
Chlorides (Cl)	306	25	1,450
Sulphates (SO_4)	297	99	580
Bicarbonates (HCO_3)	18	Undetermined.	Undetermined.

[a] Analysis by R. F. Gardner, Bureau of Soils.
[b] Analysis by F. H. Carpenter, Bureau of Soils.

NOTES.

No. 1. This water is from the so-called Salt Spring southeast of the White Sands. The spring is apparently deep-seated, and is slightly warmer than the surface waters in general. It has built a cone of gypsum about 1,000 feet in diameter by 50 feet high. Its water flows into a playa about one-half mile southeast, where it evaporates. The salt crust from this playa showed a mere trace of potash.

No. 2. This is from the Shoemaker artesian well, about one-half mile north-northeast of the Cerrito Tularosa. Its depth is unknown, but is said to be 400 feet.

No. 3. This is from a well drilled by Mr. Emry Joy in the town of Alamogordo. Its depth is unknown, but is said to be considerable. There are several other deep wells in or near the town of Alamogordo, but the waters are all fresh, and were not analyzed.

9. No deep wells have been bored in the central part of the basin, and a shallow (75-foot) hole bored in the neighborhood of the sodium sulphate deposit at Lake Lucero did not penetrate the deposits produced by the last filling and present desiccation of the lake.

Turning now to the more general matter of a possible source of potash and its present entry into the basin, the indications are strongly negative. The bordering mountains are almost entirely sedimentary rocks of Carboniferous age and of marine origin, which can not be expected to carry or yield any significant quantity of potash. The only potash-bearing rocks which could possibly contribute appreciably to the saline materials of the basin are comparatively small exposures of granites in White Mountain and the Oscura Mountains and some insignificant andesitic intrusions in the Sacramentos, the San Andreas, the Oscuras, etc. In the almost total lack of accurate surveys, it is impossible to estimate closely the area of these potash-bearing exposures, but it is safe to say that they form less than 5 per cent and probably less than 1 per cent of the drainage area of the basin. It is true that a part of the Carboniferous sedimentary series were perhaps laid down under continental conditions or in inclosed arms of the sea, and may possibly carry small quantities of various salts occluded and retained during the sedimentation. However, none of these strata is known to be markedly saline, and in any event the salt would probably be almost exclusively sodium chloride. There is no reason to expect even minor quantities of potash in these strata, and the drainage waters from them (as, e. g., No. 2 in Table III) show only traces thereof.

But the best evidence as to the possible existence or nonexistence of a source of potash is furnished by the waters of the present drain-

age. Analyses of 14 of these waters are given in Table III. Their content of potassium is uniformly low and is apparently much lower than that of stream waters in general, though this conclusion loses somewhat in surety because of the fact that the samples for analysis were not large enough for the accurate determination of such minute quantities.

In addition to the analyses quoted in the table determinations of potassium only were made on a number of other waters from various parts of the basin, and more or less complete analyses were made of 16 samples of salt crusts from salt seeps and the like. None of these materials showed more than minute traces of potassium.

Of the analyses in Table III, Nos. 13, 14, and 15 are especially instructive, since these brines are almost certainly ordinary drainage waters greatly concentrated by evaporation, with the almost entire precipitation of the gypsum originally present and the similar loss (probably) of a good part of the sodium chloride. Had any significant quantity of potassium been present in the original water, it would unquestionably have been retained and concentrated in the brine. Its nearly complete absence therefrom is very significant.

The general conclusion as to the presence of potash is entirely and strongly negative. To the questions, does it exist on the present surface, is it importantly present in the rocks of the mountains, and does it enter in the present drainage, it is possible to give an unhesitating no. The query as to the probability of buried beds must receive the same reply, but with somewhat less assurance. It is probable that several saline beds underlie the deposits of the present surface, and there is a bare chance that potash may be associated with some of them. Practically, however, this chance is negligible. Geologic considerations indicate that the buried salts probably are disseminated in clays or sands rather than existing as segregated layers, and even should some be in the latter form the association of segregated potash with them is extremely improbable. Very little potash is now entering the basin, and there is no reason to believe that the past supply was any greater. Indeed, it was probably less, for the potash-bearing rocks were previously covered with potash-poor sedimentaries and have attained exposure only by the gradual erosion of these latter. Their area of exposure is now larger than ever before.

In any event, whatever weight may be given or denied to this vanishing chance of a buried bed, it is safe to say that the chance of finding potash anywhere in the Otero is very much less than in many of the other undrained basins. Though surface deposits seem to be nowhere probable, and though direct indications of potash in buried beds are not so far known, there are literally hundreds of

TABLE III.—*Analyses of surface waters.*

[Parts per 100,000.]

Constituent.	Sample No. 1.[a]	Sample No. 2.[b]	Sample No. 3.[b]	Sample No. 4.[b]	Sample No. 5.[b]	Sample No. 6.[b]	Sample No. 7.[b]	Sample No. 8.[b]	Sample No. 9.[b]	Sample No. 10.[b]	Sample No. 11.[b]	Sample No. 12.[b]	Sample No. 13.[b]	Sample No. 14.[b]	Sample No. 15.[c]
Sodium (Na)	60	(d)	(d)	80	(d)	(d)	35	(d)	45	41	(d)	700	9,880	7,500	1,880
Potassium (K)	3	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	Trace.	6	Trace.	Trace.	120	Trace.
Calcium (Ca)	52	27	67	60	45	32	45	63	54	34	56	65	Trace.	Trace.	61
Magnesium (Mg)	17	45	26	11	42	67	44	52	18	24	32	42	1,220	2,460	77
Chlorides (Cl)	61	42	137	74	21	23	28	11	63	70	21	1,080	16,820	15,780	940
Sulphates (SO_4)	166	70	186	239	140	154	143	205	190	124	271	362	2,870	4,250	1,757
Bicarbonates (HCO_3)	15	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	21

[a] Analysis by R. F. Gardner, Bureau of Soils.
[b] Analysis by F. H. Carpenter, Bureau of Soils.
[c] Analysis by J. C. Smith, Bureau of Soils.
[d] Undetermined.

NOTES.

No. 1. From a spring in Marble Canyon, near Alamogordo.
No. 2. Tularosa River. Taken from an irrigation ditch in the town of Tularosa.
No. 3. From a large spring at the south end of the Malpais, generally known as Malpais Springs.
No. 4. From a shallow well at Black Lake Ranch. Probably taps the underflow of one of the arroyos leading into the basin from the northeast.
No. 5. From a spring 6 miles east of Black Lake Ranch. Apparently fed by surface water.
No. 6. From a shallow well at an abandoned ranch 9 miles northwest of Tularosa. Probably surface water.
No. 7. From a spring 2 miles northwest of Tularosa. Apparently fed by the underflow of the Tularosa delta.
No. 8. From a spring just northeast of the Cerrita Tularosa. Apparently fed by the underflow in one of the arroyos.
No. 9. From a spring in the third arroyo south of the Cerrita Tularosa (Grant's Ranch). Apparently fed by the underflow of this arroyo.
No. 10. From the Sutherland well, 7 miles south of the Alamogordo. Said to be 80 feet deep.
No. 11. From the Hunter well, at the southeast point of the White Sands. Water is 12 feet below the surface.
No. 12. From Salt Creek. Taken at the road crossing west of Malpais Springs.
No. 13. Brine from Salt Lake (west of Malpais Springs). Taken about 30 feet from shore, where the water was 4 inches deep.
No. 14. Brine taken from an auger hole bored into the dry bottom of the inclosed playa just west of Salt Lake. The brine rose in the hole until within 15 inches of the surface.
No. 15. Water from a hole dug 10 feet deep into the loose gypsum on the surface of South Lake playa. Collected by Mr. J. E. Ragsdale, of Alamogordo, and received from him through Mr. J. Arthur Eddy.

localities where the chance of finding such buried beds is not only greater than in the Otero Basin, but is almost immeasurably greater.

This strongly negative conclusion raises the question as to the source of the repeated rumors of the occurrence of potash in the Otero Basin. These rumors can be traced to a comparatively few individuals, and appear to be based on reports of from 1 to 11 per cent of potash (K_2O) in samples collected at several localities within the basin. Careful resampling at these localities by the writer, with subsequent analyses by F. H. Carpenter, of the Bureau of Soils, showed only traces of potash—less, in fact, than is present in ordinary soils. The previous higher results can be ascribed only to faulty analytical methods, joined, perhaps, to a faulty sampling and consequent contamination with animal excrement. As the original samples are not now available, reanalysis is impossible.

Approved.

JAMES WILSON,
Secretary of Agriculture.

THIS PUBLICATION may be procured from the Superintendent of Documents, Government Printing Office Washington, D. C., at 5 cents per copy